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**Are different forms of repetitive negative thinking associated with interpretation bias in generalized anxiety disorder and depression?**

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**Abstract**

Worry and rumination, two forms of repetitive negative thinking (RNT), are prevalent in generalized anxiety disorder (GAD) and depression. Cognitive processing biases, especially the tendency to draw negative conclusions from ambiguous information ('interpretation bias') may maintain worry and rumination. Yet, the relationship between interpretation bias and both forms of RNT has not been explored in clinical vs. non-clinical samples. In this cross-sectional study, participants with GAD ( $N = 72$ ), depression ( $N = 79$ ), or neither disorder ( $N = 71$ ) completed two tasks assessing interpretation bias, measures of worry and rumination, and reported negative thought intrusions during a behavioral task. Interpretation bias was associated with higher levels of worry, rumination, and negative thought intrusions. Both clinical groups generated significantly more negative interpretations than healthy comparison participants. These findings link interpretation bias to worry and rumination, and establish the need for research investigating the causal role of interpretation bias in maintaining RNT.

**Are different forms of repetitive negative thinking associated with interpretation bias in generalized anxiety disorder and depression?**

Worry and rumination are two styles of thinking characterized by streams of negative, relatively abstract, and repetitive thoughts. Both are associated with increased anxiety and low mood (e.g., Fresco, Frankel, Mennin, Turk, & Heimberg, 2002; Segerstrom, Tsao, Alden, & Craske, 2000). Their prevalence across a range of psychological problems has led to worry and rumination being conceptualized as part of a transdiagnostic repetitive negative thinking process (Ehring & Watkins, 2008). Yet, despite crossing diagnostic boundaries, worry and rumination are most strongly associated, and especially problematic, in two particular psychological disorders. Persistent and ostensibly uncontrollable worry is a central feature of generalized anxiety disorder (GAD; American Psychiatric Association, 2013). Rumination is a common characteristic of depression (see e.g., Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008), associated with more prolonged periods of depression and predicting new onsets of the disorder (Nolen-Hoeksema, 2000). As worry and rumination may play a role in maintaining GAD and depression, it is vital to better understand the mechanisms involved in driving these forms of repetitive negative thinking. Studies investigating features of worry and rumination are heterogeneous and often difficult to compare, but have overall found more similarities than differences between these two forms of negative thinking. Notably, both seem to share common process features. In particular, both worry and rumination are negative in content, and are perceived as unpleasant and repetitive (see Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2015; Watkins, Moulds, & Mackintosh, 2005). Differences between worry and rumination seem to mainly pertain to temporal orientation and content. For example, worry often concerns hypothetical future threats (e.g., ‘What if this bad thing happens?’). By contrast, rumination commonly regards symptoms of depression and past or ongoing concerns around failure (e.g., ‘Why can’t I ever get this right?’). Ruminative thoughts may be less

hypothetical than worry and more susceptible to daily events (Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2018). It is thus important to be mindful of differences in core content and temporal orientation when comparing worry and rumination. However, the similarities in process features between the two beg the question as to whether both worry and rumination might share underlying cognitive mechanisms.

Interpretation bias, the tendency to consistently resolve relatively ambiguous information in a negative manner, has been proposed by Hirsch and Mathews (2012) as a key cognitive process which may maintain pathological worry. Resolving ambiguity is ubiquitous in daily life. Ambiguous information involving potential future threats or negative implications of past events may be especially pertinent in relation to streams of worry and rumination. For example, if a person is worrying about an upcoming interview and wonders whether they will be able to articulate their answers, interpreting this ambiguous situation negatively will increase perceived threat. Similarly, rumination after an interview will provide opportunity for interpreting ambiguity in a negative way (e.g., an interview panelist's smile may be interpreted as indicating mockery or derision, rather than approval). These kinds of interpretations may lead to further opportunities for drawing negative conclusions when new ambiguities arise (e.g., an interviewer making notes may then be interpreted as an unfavorable, rather than promising, sign), perpetuating streams of worry and rumination.

Interpretation bias is evident across emotional disorders (see Hirsch, Meeten, Krahé, & Reeder, 2016), with some evidence for biases in individuals with diagnoses of GAD and depression in particular (e.g., Butler & Mathews, 1983; Everaert, Podina, & Koster, 2017; Eysenck, Mogg, May, Richards, & Mathews, 1991; Mathews, Richards, & Eysenck, 1989). In addition, studies with non-clinical or sub-clinical samples have also found that levels of depressive symptoms are associated with a more negative interpretation bias (e.g., Berna, Lang, Goodwin, & Holmes, 2011; Wisco & Nolen-Hoeksema, 2010). However, although interpretation bias has been hypothesized to be involved in initiating and perpetuating

repetitive negative thinking, evidence for an association between a more negative interpretation bias and worry and rumination is largely missing. This lack of studies is especially evident in clinical populations with high levels of these forms of repetitive negative thinking. Yet, revealing an association between interpretation bias and both worry and rumination would indicate that interpretation bias is related to both these maladaptive thinking styles. This, in turn, could point to a potential shared and transdiagnostic mechanism involved in these different forms of repetitive negative thinking. Furthermore, investigating interpretation bias occurring during worry and rumination may help inform approaches aimed at reducing repetitive negative thinking. This is an especially important aim given the role of worry and rumination in maintaining clinical problems (see e.g., Drost, van der Does, van Hemert, Penninx, & Spinhoven, 2014).

To our knowledge, the association between interpretation bias and levels of worry has only been investigated in one study in a non-clinical child population, which indicated that a more negative interpretation bias was related to higher trait worry (Suarez & Bell-Dolan, 2001). No cross-sectional studies to date have looked specifically at the association between interpretation bias and worry in adult clinical populations. While several experimental studies have shown that changing interpretation bias reduces worry in people with GAD and high worriers (Hayes, Hirsch, Krebs, & Mathews, 2010; Hirsch, Hayes, & Mathews, 2009; see also Discussion), these studies did not look at the baseline association between interpretation bias and worry. Examining whether higher levels of worry are indeed associated with a more negative interpretation bias is an important goal: At the most basic level, a lack of association between the two calls into question the rationale for aiming to ameliorate worry by changing interpretation bias.

Regarding rumination, research in non-clinical samples has demonstrated a positive association between negative interpretation bias and levels of rumination (Everaert, Grahek, et al., 2017; Mor, Hertel, Ngo, Shachar, & Redak, 2014; Wisco, Gilbert, & Marroquín, 2014).

Moreover, it seems that for non-clinical dysphoric individuals, interpretation bias is evident during current bouts of rumination: when inducing a period of rumination, dysphoric individuals and individuals with high levels of ‘brooding’ (a facet of rumination) made more negative interpretations compared to individuals in non-rumination conditions (i.e., distraction / external focus; Hertel & El-Messidi, 2006; Hertel, Mor, Ferrari, Hunt, & Agrawal, 2014, experiment 1).

Although there is an indication that interpretation bias is related to rumination, no cross-sectional studies have assessed the association between interpretation bias and worry in adults, and critically none have investigated interpretation bias in relation to *both* worry and rumination within the same study. Examining both worry and rumination within the same study is important because any differences found in the extent to which interpretation bias is linked to worry and rumination may otherwise be related to differences in design and assessment between studies. Furthermore, worry and rumination have been conceptualized as part of a repetitive negative thinking process (Ehring & Watkins, 2008; Kircanski et al., 2015). Yet, is unclear whether these forms of repetitive negative thinking also share common underlying cognitive processes. To address this gap in the literature, we assessed the relationship between interpretation bias and levels of both worry and rumination.

Furthermore, we examined shared and unique variance between interpretation bias, worry, and rumination. In addition to measuring self-reported levels of worry and rumination, we also included a more behavioral repetitive negative thinking task measuring negative thought intrusions reported over a period of five minutes before and after an induced period of worry or rumination (see e.g., Hirsch, Mathews, Lequertier, Perman, & Hayes, 2013). This task provides a dynamic state measure of negative thinking and serves as a proxy for streams of worry and rumination.

Extant studies into worry and rumination have been conducted in non-clinical samples (see above). While these studies are informative regarding associations between interpretation

bias and worry and rumination, they do not assess whether interpretation bias is more pronounced in individuals with pathological levels of worry and rumination. To address this issue, we examined interpretation bias in relation to both worry and rumination in individuals with a clinical diagnosis of GAD or depression. We compared these groups with each other, and contrasted these clinical groups with a healthy comparison group.

In sum, this cross-sectional study goes beyond previous research in several ways: First, we examined the relationship between interpretation bias and both levels of worry and rumination, assessed by self-report questionnaire and using a behavioral repetitive negative thinking task. Second, we investigated whether negative interpretation bias would be greater in individuals with a diagnosis of GAD or depression vs. a healthy comparison group. We employed two different ‘offline’ (i.e., reflective, not based on reaction times) measures of interpretation bias: the Scrambled Sentences Test and the Recognition Test. Both are widely used in anxiety and depression research to assess interpretation bias (see e.g., Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002; Rude, Valdez, Odom, & Ebrahimi, 2003; Rude, Durham-Fowler, Baum, Rooney, & Maestas, 2010; Everaert, Duyck, & Koster, 2014; Everaert, Tierens, Uzieblo, & Koster, 2013; Mathews & Mackintosh, 2000; Sanchez, Everaert, De Putter, Mueller, & Koster, 2015). We chose the Recognition Test to complement the Scrambled Sentences Test because it includes foil statements and is thus more oblique and less susceptible to demand and selection bias (see Hirsch et al., 2016, Supplementary Materials). Taking into account that measures should be tailored to the phenomena in question (see e.g., Hirsch et al., 2016), both the Scrambled Sentences Test and Recognition Test used subsets of items specifically relating to worry or rumination.

We predicted that indices of interpretation bias would be correlated with worry, rumination, and the number of negative thought intrusions; that is, that a more negative interpretation bias would be associated with greater levels repetitive negative thinking. Furthermore, we expected that individuals with GAD or depression (i.e., both clinical groups)



would display a more negative interpretation bias than the healthy comparison group. Given studies demonstrating a link between interpretation bias and both anxiety and depression (e.g., Butler & Mathews, 1983), we proposed that despite possible differences in the presumed dominant form of repetitive negative thinking in each disorder (worry in GAD and rumination in the depressed group), the role of cognitive biases as basic underlying processes would be similar in the two groups. Specifically, we predicted that in terms of interpretation bias, the two clinical groups would differ from the healthy comparison group but not from each other.

## Method

### Participants

Participants were recruited from the community via advertisements placed on websites and in newspapers, as well as via university circular emails. Participants were aged between 18 – 65 years and met diagnostic criteria for either current major depressive episode (DEP group) OR generalized anxiety disorder (GAD group) OR did not currently meet diagnostic criteria for either disorder (healthy comparison group) on the Structured Clinical Interview for DSM-V (SCID; First, Williams, Karg, & Spitzer, 2015) administered at the screening stage.

Participants were included from two sources: Participants with a diagnosis of GAD or depression ( $n = 151$ ) were drawn from a larger multi-session study, described in Hirsch et al. (2018). We included all participants who completed the larger study, as well as those who attended at least the first session (thus, the  $n$  is greater here than that included in Hirsch et al., 2018). Hirsch et al. (2018) excluded participants without a diagnosis of GAD or depression. However, as these participants still had elevated levels of anxiety and depression symptoms (a pre-requisite for diagnostic screening in that study, see Hirsch et al., 2018), we recruited a separate group of participants for the healthy comparison group<sup>1</sup>. To ensure consistency

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<sup>1</sup>The healthy comparison group comprised individuals without a current diagnosis of GAD or depression. However, participants may have had GAD or depression in the past. Further, we cannot rule out that they had

between samples, exclusion criteria stipulated in Hirsch et al. (2018) applied to all participants included and recruited for the present study. In particular, prior to inviting participants to the SCID screening, we excluded individuals with severe depression ( $>23$  PHQ-9 total score), past or current risk to self (self-harm in past 12 months/suicide attempt in last five years/PHQ-9 suicidal ideation item 9 scored  $>1$ ), comorbid psychosis, bipolar disorder, borderline personality disorder or substance abuse, non-normal/not corrected to normal hearing as well as current or recent (past six months) psychological treatment or changes to psychotropic medication in the last three months. Furthermore, participants with diagnoses of *both* GAD and depression were excluded. This decision was made in order to examine the association between interpretation bias and worry and rumination in groups whose dominant form of repetitive negative thinking was either worry or rumination. Comorbidity amongst these disorders is generally high; however, the exclusion criteria pertaining to risk meant that individuals with more severe depression and potentially higher likelihood of comorbidity were excluded prior to the SCID screening stage. Specifically, in the sample of participants included from the larger clinical study, only 12.8% of participants screened for diagnosis of depression or GAD on the SCID were excluded on the basis of meeting criteria for both disorders (the majority were excluded for not meeting diagnostic criteria for either disorder; see Hirsch et al., 2018, for more detail).

The final sample consisted of  $N = 222$  participants, of which  $n = 79$  were in the DEP group,  $n = 72$  in the GAD group, and  $n = 71$  in the healthy comparison group. An independent rater, blind to group, coded a randomly selected subset (20%) of diagnostic interviews to check diagnosis (GAD, DEP, neither GAD nor DEP). Inter-rater agreement was excellent (Cohen's kappa = .96).

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diagnoses other than GAD or depression, although note the control group's low mean scores on self-reported mood and anxiety measures, which are within healthy range (see Table 1).

Participants were predominantly British (73.8%); a minority came from other European (13.6%) or overseas (12.6%) countries. Groups did not differ by country of origin,  $\chi^2(4) = 6.06, p = .195$ . Participants' highest level of education was most commonly Bachelor degree (42.5%), followed by secondary education (28.0%), Master's degree (20.4%), other (e.g., higher national diploma; 7.7%), and doctoral degree (1.4%); the groups did not differ by highest level of education,  $\chi^2(8) = 8.42, p = .394$ . Mean age was  $M = 31.2$  years ( $SD = 11.3$ ) in the DEP group,  $M = 28.0$  ( $SD = 9.5$ ) in the GAD group, and  $M = 28.5$  ( $SD = 11.0$ ) in the comparison group; mean age did not differ between groups,  $F(2, 219) = 234.77, p = .128$ . The gender ratio (F / M) was 59 / 20 in the DEP group, 62 / 10 in the GAD group and 52 / 19 in the comparison group, and the groups did not differ in respect to number of women to men,  $\chi^2(2) = 4.19, p = .123$ .

## Design

The study employed a quasi-experimental correlational design. Three groups (DEP, GAD, healthy comparison) completed two measures of interpretation bias, self-report questionnaires of anxiety, depression, worry and rumination, and a behavioral repetitive negative thinking task in which participants reported negative thought intrusions. We examined associations between scores on the measures of interpretation bias and levels of worry and rumination as well as number of negative thought intrusions (controlling for anxiety and depression symptoms) and compared the groups on their interpretation bias scores. As scales on both interpretation bias measures ranged from negative interpretations to positive interpretations, the measures were scored such that low scores reflected a more negative interpretation bias.

## Materials and Measures

### Interpretation bias measures.

*Scrambled sentences test* (SST; adapted from Wenzlaff & Bates, 1998, 2000): The SST involves using five of six words, presented in a random order, to produce the first grammatically correct sentence that comes to mind. This sentence, by the nature of the task, can be either positive or negative in valence. Participants were each presented with 20 scrambled sentences; half the sentences were selected to relate to depressive rumination (taken from Wenzlaff & Bates, 1998, 2000) and half were generated by the authors to relate to anxiety and worry (in a series of validation studies, the worry related items were found to have excellent internal consistency and split-half reliability; Krahé, Meeten et al., in prep). An example worry-related sentence was, “easy job hard finding a is”, which could be unscrambled to form the sentence “finding a job is easy” (positive interpretation) or “finding a job is hard” (negative interpretation). An example item for the rumination-related sentences was “myself in disappointed am confident I”, which could be unscrambled to make the sentence “I am confident in myself” (positive interpretation) or “I am disappointed in myself” (negative interpretation). Participants were randomly assigned to complete one of two sets of mixed worry and rumination-related items. There was no difference in interpretation bias between sets ( $t(219) = -0.21, p = .836$ )<sup>2</sup>, and no interaction between group and set ( $\chi^2(2) = .29, p = .867$ ), and thus we collapsed the data across sets for analyses. Participants were required to ‘unscramble’ as many of the 20 sentences as possible within five minutes, while holding in mind a string of six digits (serving as a cognitive load; see Wenzlaff & Bates, 1998, 2000), which they were asked to recall at the end of the task. An overall SST index was calculated for each participant by dividing the number of positive sentences generated by the overall number of grammatically correct sentences generated. Thus, the index ranged from 0 – 1,

<sup>2</sup> Furthermore, results did not change when controlling for set in analyses.

with lower scores indicating a more negative interpretation bias. The SST was scored in this direction to be consistent with Hirsch et al. (2018).

*Recognition Test* (RT; adapted from Mathews & Mackintosh, 2000): The RT involves rating the similarity of statements to previously presented scenarios. It consists of two phases: in the first phase, participants read 20 ambiguous scenarios and completed a comprehension question after each one. For example, participants saw the scenario:

### **The car park**

It is late at night and you are in a multi-storey car park trying to find your car.

You have been looking for about ten minutes and still cannot find it. You hear a noise behind you and see a shadow of something.

*Question:* Did you find your car right away? (Correct answer: No)

In the second phase, participants were presented with four statements per previously seen scenario and were asked to rate how similar in meaning these statements were to the original scenario on a scale from 1 (*very different in meaning*) to 4 (*very similar in meaning*). Two statements were ‘target’ statements relating to the ambiguity in the scenario, of which one described a positive and one a negative disambiguation of the scenario. The other two statements were ‘foils’ unrelated to the ambiguity (again one was positive and one negative) and were included as filler items only. For example, the above scenario was presented with the following statements:

You see a security person approaching to help you. (Positive target)

You see someone coming towards you looking threatening. (Negative target)

You see some money on the floor and pick it up. (Positive foil)

You see that you have forgotten your ticket and will have to pay a fine. (Negative foil)

Participants were randomly assigned to complete one of three sets of items; there was no difference in interpretation bias between sets ( $F(2, 217) = .54, p = .583$ )<sup>2</sup> and thus we collapsed the data across sets for analyses. A RT index was computed for each participant by subtracting mean similarity ratings for negative targets from mean similarity ratings for positive targets. Thus, lower scores denoted greater similarity ratings to negative vs. positive targets i.e., a more negative interpretation bias.<sup>3</sup>

**Worry and rumination measures.** Worry was measured using the 16-item Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990; example item: “*I am always worrying about something*”). Items were rated on a scale from 1 (*not at all typical of me*) to 5 (*very typical of me*) and summed (after reverse-scoring appropriate items) to produce an overall score, with higher scores denoting greater worry. Rumination was assessed using the 22-item Ruminative Response Scale (RRS; Nolen-Hoeksema & Morrow, 1991; example item: [how much do you generally] “*think about how sad you feel*”). Items were rated on a scale from 1 (*almost never*) to 4 (*almost always*) and summed, with higher scores denoting greater rumination. Cronbach’s alphas in the present study were  $\alpha = .93$  for the PSWQ and  $\alpha = .92$  for the RRS. Both the PSWQ (Meyer et al., 1990) and the RRS (Just & Alloy, 1997) have been shown to have good test-retest reliability.

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<sup>3</sup> We computed a bias index in order to obtain one score for interpretation bias on the RT and to make SST and RT tasks more readily comparable (both scored on a dimension from negative to positive, as in Hirsch et al., 2018). We checked that participants indeed endorsed targets more than foils; this was the case, irrespective of valence ( $b = .68, SE = .04, p < .001; M = 2.46, SE = .02$  for targets and  $M = 1.81, SE = .02$  for foils). Moreover, whilst not the purpose of the present paper, this task is sometimes analyzed using an ANOVA. Therefore, we also ran our group analysis (see Statistical Analyses section) as a mixed ANOVA with group as between-subjects factor and valence and target/foils as within-subjects factors, which revealed the intended 3-way interaction ( $F(2, 651) = 4.30, p = .014$ ). Follow-up tests showed that for the negative valence, there was a main effect of target/foils (targets were endorsed more than foils) and group (clinical groups endorsed more negative material than healthy comparison participants) but the interaction was non-significant. For the positive valence group, there was a main effect of target/foils (targets were endorsed more than foils) and group (clinical groups endorsed less positive material than healthy comparison participants), and a significant interaction between target/foils and group (all groups endorsed targets significantly more than foils; this was most pronounced in the healthy comparison group).

**Depression and anxiety symptoms.** We used the 9-item Patient Health Questionnaire (PHQ-9; Kroenke & Spitzer, 2002) and the 7-item GAD-7 (Spitzer, Kroenke, Williams, & Löwe, 2006) to measure depression and anxiety symptoms, respectively, in the last two weeks (example item for depression: “*Feeling down, depressed, or hopeless?*”; example item for anxiety: “*Feeling nervous, anxious, or on edge?*”). On each measure, items were rated on a 4-point Likert scale ranging from 0 (*not at all*) to 3 (*nearly every day*) and responses were summed to give the overall score, with higher scores denoting greater depression / anxiety symptoms. Cronbach’s alphas were  $\alpha = .83$  for the PHQ-9 and  $\alpha = .91$  for the GAD-7.

**Behavioral repetitive negative thinking task.** This task is a state measure of negative thought intrusions, which often initiate a period of repetitive negative thinking, and can be seen as a more behavioral proxy for streams of worry and rumination than self-report questionnaires. Based on the original breathing focus task/worry task, which has been widely used in past research (Hayes et al., 2010; Hirsch et al., 2009; Hirsch et al., 2013; Ruscio & Borkovec, 2004), participants focused on their breathing for five minutes and indicated at randomly cued intervals whether they were focusing on their breathing or experiencing a thought intrusion, which they then categorised as negative or otherwise (neutral, positive). Participants then identified a salient current or past worry (GAD group) or rumination (DEP group) topic; the healthy comparison group chose either worry or rumination, depending on what they felt was dominant for them on the day. After discussing this topic briefly with the experimenter, participants were asked to silently worry / ruminate about the topic in their usual manner for five minutes, while the experimenter left the room. This repetitive negative thinking induction was designed to activate worry / rumination, and was followed by another five-minute breathing focus period, with sampling as before. The outcome measure was the mean number of negative thought intrusions reported per time period (pre- or post-worry/rumination induction).

## Procedure

Participants took part in one experimental session lasting approximately 1 hour. Questionnaire measures were completed online within 24 hours prior to the session, and diagnosis / diagnostic status was confirmed by administering the GAD and depression modules of the SCID either at a screening phone call before the session or as a screener at the beginning of the session. Participants provided informed consent and completed the SST, RT and behavioral repetitive negative thinking task in this order. Clinical participants subsequently completed further tasks which are not reported here. Ethical approval was granted by the ethics committee of the authors' university. The study was carried out carried out in accordance with the World Medical Association Declaration of Helsinki.

## Statistical Analyses

All analyses were carried out in Stata 14 (StataCorp, 2015). We initially computed correlations between the questionnaire measures and examined group differences on these measures. To investigate our first hypothesis that interpretation bias would be associated with levels of worry and rumination, we examined correlations between interpretation bias, as measured by SST and RT, and each form of repetitive negative thinking. To see whether negative thought intrusions were predicted by interpretation bias, we specified multilevel models, given that breathing focus period (level 1) was nested within individuals (level 2). For SST and RT separately, we specified a model with number of negative thought intrusions as the outcome variable, and interpretation bias score, breathing focus period (pre-vs. post-worry / rumination induction) and their within-level interaction as predictors.. Furthermore, to check that associations were not explained by anxiety and depression symptoms, we conducted regression analyses (with bootstrapped standard errors in the case of non-normally distributed data) with interpretation bias score as the outcome variable, worry and rumination scores as predictor variables, and controlled for anxiety and depression symptoms. For



negative thought intrusions, we re-ran the above analysis and controlled for anxiety and depression symptoms. Second, to examine whether clinical groups showed a more negative interpretation bias than the healthy comparison group, regression analyses were carried out with interpretation bias score as the outcome variables and group (three levels: DEP, GAD, healthy comparison) as categorical predictor variable. Wald tests (chi square) were conducted to test linear hypotheses about the parameters of the model. Sidak-corrected pairwise comparisons as well as one-sample t-tests were used to follow up group differences.

## Results

### Descriptive Statistics, Correlations, and Group Differences

Mean questionnaire scores by group are presented in Table 1. Mean scores for worry and rumination in the clinical groups were high and similar to previous studies with clinical populations (e.g., Fresco, Mennin, Heimberg, & Turk, 2003; Pearson, Brewin, Rhodes, & McCarron, 2008; Rimes & Watkins, 2005). Overall, worry, rumination, anxiety and depression were significantly moderately to strongly correlated with each other (see Table 1). Furthermore, higher levels of worry ( $r = .52, p < .01$ ) and rumination ( $r = .55, p < .01$ ) were significantly correlated with a greater number of negative thought intrusions on the behavioral repetitive negative thinking task (averaged across both time periods<sup>4</sup>). Comparing questionnaire scores among groups, both clinical groups had significantly higher levels of worry, rumination, depression and anxiety symptoms than the healthy comparison group (see Table 1). Furthermore, the depressed group reported higher levels of trait rumination than did the GAD group, while the GAD group reported higher levels of trait worry than did the depressed group. The depressed group reported higher levels of depressive symptoms than the

<sup>4</sup> Worry and rumination were also correlated with negative intrusions reported at each time period separately (pre- worry/rumination induction:  $r = .49, p < .01$  for worry,  $r = .53, p < .01$  for rumination; post- worry/rumination induction:  $r = .47, p < .01$  for worry,  $r = .48, p < .01$  for rumination).

GAD group, but the two clinical groups did not differ from each other in terms of self-reported anxiety symptoms.

### **Are Levels Of Worry And Rumination Associated With A More Negative Interpretation Bias?**

The two interpretation bias measures were significantly moderately correlated ( $r = .52$ ,  $p < .01$ ). On the *Scrambled Sentences Test (SST)*, one person was excluded for failing to complete any grammatically correct sentences, leaving  $N = 221$  for this analysis. For the SST, both levels of worry ( $r = -.72$ ,  $p < .01$ ) and rumination ( $r = -.68$ ,  $p < .01$ ) were significantly strongly negatively correlated with SST index (see Figure 1, left panel), indicating that higher levels of worry and rumination were associated with a more negative interpretation bias (i.e., more negative interpretations generated). When controlling for anxiety and depression symptoms, both worry ( $b = -.005$ , bootstrapped  $SE = .00$ ,  $p < .001$ , 95% CIs  $[-.008, -.002]$ ) and rumination ( $b = -.003$ , bootstrapped  $SE = .00$ ,  $p = .009$ , 95% CIs  $[-.006, -.001]$ ) predicted SST index, with higher levels of worry and rumination predicting more negative interpretations. Adding the two critical variables (i.e., worry and rumination) into the model containing the covariates (anxiety and depression) explained a further 5.6% of the variance ( $p < .001$ ; both worry and rumination predicted unique additional variance), with the full model explaining 58.0% of the variance. Furthermore, SST index predicted negative thought intrusions reported by participants ( $b = -4.65$ ,  $SE = .55$ ,  $p < .001$ , 95% CIs  $[-5.72, -3.58]$ ), in that more negative interpretations (a lower score) predicted more negative thought intrusions.<sup>5</sup>

On the *Recognition Test (RT)*, two participants failed to complete the task correctly, leaving  $N = 220$  for this analysis. As on the SST, on the RT both levels of worry ( $r = -.46$ ,  $p$

<sup>5</sup> These results did not change when controlling for depression and anxiety symptoms and this effect was found across breathing focus period (pre / post worry/rumination induction): the effect of breathing focus period ( $b = -.28$ ,  $SE = .34$ ,  $p = .400$ , 95% CIs  $[-.94, .37]$ ) and the SST index by breathing focus period interaction ( $b = .01$ ,  $SE = .52$ ,  $p = .988$ , 95% CIs  $[-1.02, 1.04]$ ) were non-significant.

<.01) and rumination ( $r = -.44, p < .01$ ) were significantly moderately negatively correlated with RT index, again indicating that higher levels of worry and rumination were associated with a more negative interpretation bias; see Figure 1 (right panel). When controlling for anxiety and depression symptoms, both worry ( $b = -.013, SE = .01, p = .028, 95\% \text{ CIs } [-.025, -.001]$ ) and rumination ( $b = -.016, SE = .00, p = .001, 95\% \text{ CIs } [-.025, -.006]$ ) predicted RT index, with higher worry and rumination scores predicting lower RT index, i.e., more negative than positive interpretations. Adding worry and rumination into the model containing anxiety and depression symptoms explained a further 7.1% of the variance ( $p < .001$ ; again, both worry and rumination predicted unique additional variance), with the full model explaining 25.5% of the variance. Furthermore, RT index predicted the number of negative thought intrusions reported by participants ( $b = -1.10, SE = .19, p < .001, 95\% \text{ CIs } [-1.48, -.72]$ ), in that a lower index score (more negative interpretations) predicted more negative thought intrusions.<sup>6</sup>

Thus, confirming our hypothesis, we found moderate to strong associations between a more negative interpretation bias and higher levels of worry, rumination, and negative thought intrusions, which were not accounted for by anxiety and depression symptoms.

### **Do Individuals With GAD Or Depression Make More Negative Interpretations Than Individuals Without These Disorders?**

On the SST, group significantly predicted SST index,  $\chi^2(2) = 240.30, p < .001$ . Marginal means are presented in Figure 2 (left panel). Follow-up Sidak-corrected pairwise comparisons showed that both the DEP group and the GAD group had significantly lower

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<sup>6</sup> These results did not change when controlling for depression and anxiety symptoms. As with the SST, this effect was found across breathing focus period; the RT index score by breathing focus period interaction was non-significant ( $b = -.13, SE = .17, p = .463, 95\% \text{ CIs } [-.47, .21]$ ). Breathing focus period (pre- vs. post-worry/rumination induction) also predicted number of negative intrusions ( $b = -.27, SE = .14, p = .048, 95\% \text{ CIs } [-.54, -.002]$ ): participants reported more negative thought intrusions after the worry/rumination induction ( $M = 2.83, SE = .15$ ) than before the induction ( $M = 2.55, SE = .15$ ).

scores (i.e., made significantly more negative interpretations) than did the comparison group (both  $p$ 's  $< .001$ ), but did not differ from each other ( $p = .895$ ). Thus, the two clinical groups showed a greater negative interpretation bias compared with the healthy comparison group. On the RT, group significantly predicted RT index,  $F(2, 217) = 30.83, p < .001$ ; marginal means are presented in Figure 2 (right panel). Akin to the SST, follow-up Sidak-corrected pairwise comparisons showed that both the DEP group and the GAD group had significantly lower RT scores (i.e., made more negative than positive interpretations) than did the healthy comparison group (both  $p$ 's  $< .001$ ). The two clinical groups did not differ significantly from each other ( $p = .058$ ). However, while the DEP group's mean score did not differ significantly from zero, that is, the mid-point of the scale (one-sample  $t(76) = -0.12, p = .908$ ), the GAD group's mean score did differ significantly from zero in the negative direction (one-sample  $t(71) = -3.51, p < .001$ ). Overall, consistent with our hypothesis, the two clinical groups showed a more negative interpretation bias than the healthy comparison group on both measures of interpretation bias.

## Discussion

This cross-sectional study examined the association between interpretation bias and two types of repetitive negative thinking, namely worry and rumination, in a large sample of individuals with either GAD, depression, or without either disorder. In support of our hypotheses, we found that, across groups, a more negative interpretation bias was moderately to strongly associated with repetitive negative thinking, that is, with higher levels of worry, rumination and negative thought intrusions (a behavioral proxy of streams of repetitive negative thinking). As well as this linear relationship, we found that individuals with a diagnosis of GAD or depression displayed a significantly more negative interpretation bias compared to the healthy comparison group; in particular (discussed in more detail below), they appeared to lack the positive interpretation bias displayed in the healthy comparison

group. Together, these findings provide compelling and novel evidence for a clear association between negative interpretation bias and both worry and rumination as assessed by self-report questionnaire and by a more behavioral measure of thought intrusions. To our knowledge, this is the first study to establish the association between interpretation bias and both worry and rumination within the same study, and the first to examine the link between interpretation bias and worry and rumination in clinical samples. As such, it bridges an important gap in the current literature. It demonstrates that different forms of repetitive negative thinking may be characterized by shared cognitive processes and also examines these processes in groups with pathological levels of repetitive negative thinking (as we discuss in more detail below).

Worry and rumination share common features. Both are characterized by negative and repetitive thoughts and a perceived lack of control (see Kircanski et al., 2015). However, they also differ in aspects such as temporal orientation. Worry seems more future-oriented while rumination is more present/past-focused (Kircanski et al., 2015; Watkins et al., 2005). In the current study, we aimed to better understand whether worry and rumination may both be underpinned by the same cognitive mechanisms. To do this, we measured levels of worry and rumination using separate questionnaire measures, and looked at their relationship with interpretation bias. Interpretation bias appears to operate similarly in both worry and rumination, since interpretation bias was related to both worry and rumination – to the same degree – and furthermore this was evident on two separate measures of interpretation bias (the SST and RT; see Figure 1). Although we examined this association cross-sectionally, the current findings are in line with theoretical accounts positing that interpretation bias may play a role in the maintenance of worry (Hirsch & Mathews, 2012) and extend these to provide further evidence that rumination is also associated with interpretation bias. Furthermore, these findings indicate that worry and rumination may share interpretation bias as a common cognitive process and highlight similarities between these forms of repetitive negative

thinking. However, it should be noted that although worry and rumination were strongly correlated with each other and showed the same pattern of results in regards to their relationship with interpretation bias, both worry and rumination also predicted unique variance in SST and RT scores.

The present study also demonstrated that interpretation bias was more pronounced in individuals with pathological levels of worry and rumination, namely those with GAD and depression, compared to individuals without these disorders. These findings were apparent when controlling for anxiety and depression symptoms, indicating that clinical status or level of impairment alone could not explain these results. Rather, clinical participants with GAD (vs. sub-clinical participants) report more negative thought intrusions and a reduced ability to stop such thoughts (Hirsch et al., 2013). It should be noted that we excluded participants with recent self-harm and high levels of suicidal ideation. While future research could be more inclusive, our mean PHQ-9 score in the depression group was 16, which is well above the threshold for caseness (a score of 10; Gyani, Shafran, Layard, & Clark, 2013). We thus believe that our results still generalize to many individuals with GAD or depression.

The clinical groups did not differ from each other in terms of their level of interpretation bias. This lack of a difference again points to interpretation bias playing a similar role in relation to both worry and rumination in individuals with clinical disorders characterized by high levels of these forms of repetitive negative thinking. As repetitive negative thinking is prevalent across a range of disorders (see Ehling & Watkins, 2008) and is proposed to operate transdiagnostically, we do not argue that the association between interpretation bias and worry and rumination is limited to GAD and depression. Indeed, we found this association across all groups, including the healthy comparison group. Rather, we chose GAD and depression because worry and rumination are hallmark features of these disorders. To this end, we recruited participants with either GAD *or* depression. Both groups

had high levels of worry and rumination (compared to a healthy comparison group).

However, in line with the view that worry is particularly problematic in GAD and rumination in depression, participants with GAD reported even higher levels of worry than participants with depression, and vice versa for rumination. As the first study to demonstrate the link between interpretation bias and both worry and rumination within the same study, future studies could now extend this to include participants with comorbid GAD and depression, and diagnoses other than depression or GAD, in which repetitive negative thinking occurs. The present research lays the ground work for such future studies.

Although GAD and depressed groups did not differ significantly from each other in terms of degree of negative interpretation bias, results on the RT, in which a score of zero denotes an equal number of positive and negative interpretations made (see Figure 2), showed that the depressed group scored close to zero, while the GAD group had a more negative score, which differed significantly from zero. This may indicate that the depressed group showed a lack of the positive interpretation bias seen in the healthy comparison group, whereas the GAD group displayed a more negative bias than the healthy comparison group, although the difference between the two clinical groups was not significant. A lack of the positive bias seen in healthy samples, rather than an overtly negative bias, has been found in other emotional disorders such as social anxiety disorder (Amir, Prouvost, & Kuckertz, 2012; Hirsch & Mathews, 2000). Tasks such as the RT, which have a mid-point (equal positive/negative interpretations), may be useful for further untangling whether participants display a lack of a positive bias or the presence of a negative interpretation bias in future studies.

In the present study, we used two ‘offline’ measures of interpretation bias which allowed for reflection on the ambiguous material (though not completely time unlimited, in the case of the SST), rather than ‘online’ measures in which participants make speeded

responses to index interpretations that are generated at the time the ambiguity is first encountered (e.g., Hirsch & Mathews, 2000; see Hirsch et al., 2016, for a detailed discussion of ‘offline’ vs. ‘online’ measures). Although ‘offline’ tasks are widely used, an advantage of combining them with ‘online’ tasks is the ability to examine interpretations generated at the moment at which information is first encountered, rather than just interpretations made after having had an opportunity for reflection. Thus, using both kinds of task in future research could tell us whether resolving ambiguity is a more automatic or more reflective process. For example, in the present study, we were unable to assess whether participants made both positive and negative interpretations, and then rejected one in favour of the other, or whether participants made only the interpretation they endorsed on our measures.

A limitation of our study was its cross-sectional nature. While interpretation bias was strongly related to worry, rumination, and negative thought intrusions, in the present study we cannot draw any conclusions as to whether it plays a causal role in maintaining these forms of repetitive negative thinking. However, research using ‘cognitive bias modification’ paradigms to train a certain interpretive style has found that changing interpretation bias may lead to corresponding changes in worry (Hirsch et al., 2009; Hayes et al., 2010) and rumination (Hertel et al., 2014, experiment 2), supporting a causal link between interpretation bias and repetitive negative thinking and indicating that interpretation bias is not a result or concomitant of worry and rumination. Indeed, the longer-term effects of changing interpretation bias on worry and rumination are now being explored (Krahé, Mathews, Whyte, & Hirsch, 2016; Hirsch et al., 2018; Hirsch et al., under review). Nevertheless, the current paper provides novel and much-needed cross-sectional evidence for the relationship between interpretation bias and levels of both worry and rumination, and constitutes the first study in adults to demonstrate that worry is correlated with negative interpretation bias.



A further strength of the present study was the large sample of clinically anxious and depressed participants recruited, the use of two separate interpretation bias measures, and that we assessed the relationship between interpretation bias and both worry and rumination within the same study. Of the different forms of repetitive negative thinking, worry and rumination are perhaps most similar. In future research, it would be thus be interesting to investigate whether interpretation bias is also related to other forms of repetitive negative thinking that involve more mental imagery, such as obsessions and intrusive memories.

We focused on interpretation bias as one cognitive process posited to maintain worry and rumination, but this process is thought to operate in interaction with other biases (see the combined cognitive biases hypothesis; Hirsch, Clark, & Mathews, 2006) as well as levels of attentional control and types of mentation style (Hirsch & Mathews, 2012). Thus, future research could assess the interplay between interpretation bias and other cognitive processes (e.g., attentional biases and memory biases). The Scrambled Sentences Test may be a useful task in this regard. It can be adapted to also yield measures of attentional bias (whether participants initially attend to the negative or positive word) and memory bias (recall of constructed sentences), alongside interpretation bias (see Everaert et al., 2014). This addapted form of the task could therefore be employed to study how different cognitive processes might interact in relation to both worry and rumination.

In conclusion, the present study found that negative interpretation bias was moderately to strongly associated with worry and rumination. Furthermore, individuals with pathological levels of worry and rumination, namely those with a diagnosis of GAD or depression, displayed a more negative interpretation bias than individuals without these disorders (that is, lacked a positive bias seen in healthy individuals). Together, these findings provide novel support for a relationship between interpretation bias and maladaptive repetitive negative thinking.

### **Authors' contribution**

C.K. and C.R.H. designed the study. Testing and data collection were performed by J.W., L.B., and S.L. Data analysis was performed by C.K., and C.K. and C.R.H. drafted the paper. All authors approved the final version of the paper for submission.

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### **Declaration of Conflicting Interests**

The authors declared no conflicts of interest with respect to the authorship or the publication of this article.

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Table 1. *Descriptive Statistics and Correlations for Self-Report Questionnaires and ANOVA Results for Group Differences.*

Means (SD)				Correlations				ANOVA	
	DEP	GAD	HC	PHQ-9	GAD-7	PSWQ	RRS	ANOVA results	Pairwise comparisons (Sidak-adjusted)
PHQ-9	16.0 (4.5)	13.2 (4.1)	2.6 (3.5)	1				$F(2,219) = 222.6, p < .001$	DEP vs. HC ( $p < .001$ ); GAD vs. HC ( $p < .001$ ); DEP vs. GAD ( $p < .001$ )
GAD-7	13.2 (3.7)	14.4 (3.2)	2.7 (4.0)	.82*	1			$F(2,219) = 220.3, p < .001$	DEP vs. HC ( $p < .001$ ); GAD vs. HC ( $p < .001$ ); DEP vs. GAD ( $p = .128$ )
PSWQ	64.4 (7.4)	69.1 (6.2)	37.1 (8.3)	.75*	.86*	1		$F(2,219) = 397.9, p < .001$	DEP vs. HC ( $p < .001$ ); GAD vs. HC ( $p < .001$ ); DEP vs. GAD ( $p < .001$ )
RRS	62.6 (10.6)	57.9 (11.8)	30.8 (9.8)	.80*	.74*	.73*	1	$F(2,219) = 186.0, p < .001$	DEP vs. HC ( $p < .001$ ); GAD vs. HC ( $p < .001$ ); DEP vs. GAD ( $p < .022$ )

\* = correlation significant at  $p < .01$

Note: DEP = Depression; GAD = Generalized Anxiety Disorder; HC = Healthy comparison group; PHQ-9 = Patient Health Questionnaire (measure of depression); GAD-7 = Generalized Anxiety Disorder scale (measure of anxiety); PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale

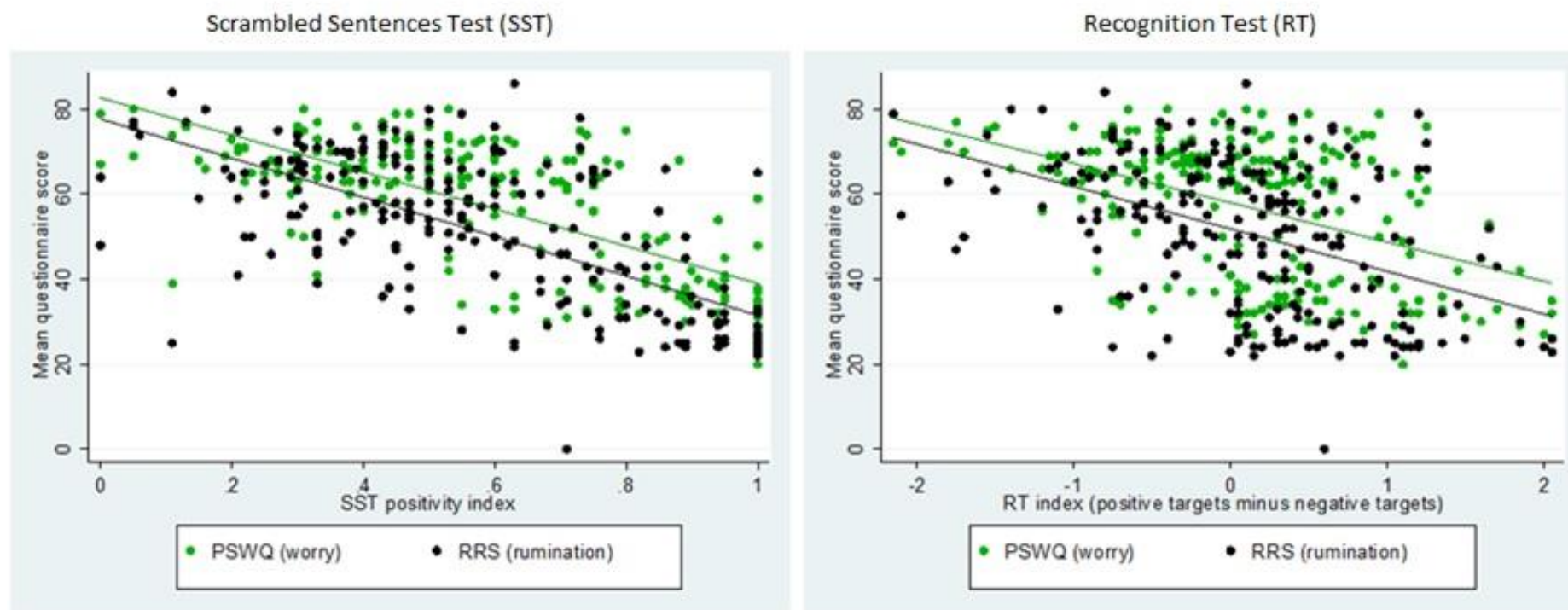


Figure 1. Association Between Scrambled Sentences Test Index (Left Panel) And Recognition Test Index (Right Panel) With Levels Of Self-Reported Worry And Rumination Across Groups.

Note. SST = Scrambled Sentences Test; RT = Recognition Test; PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale

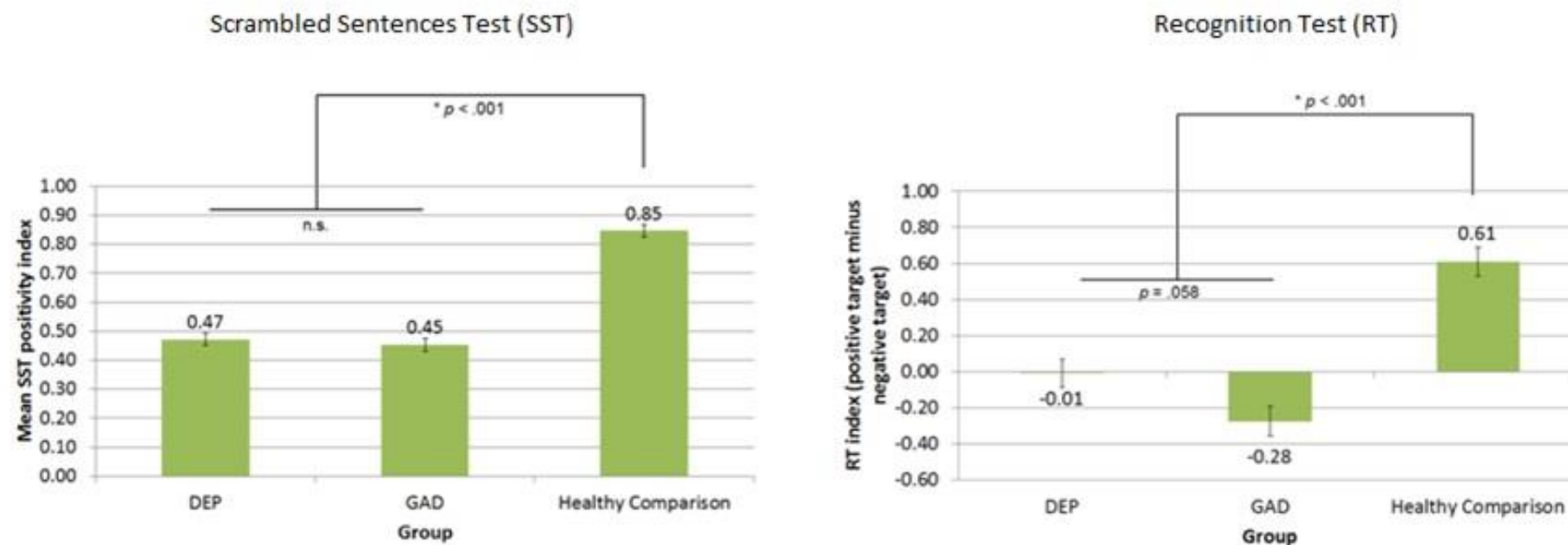


Figure 2. Results For Scrambled Sentences Test (Left Panel) And Recognition Test Index (Right Panel). Error Bars Indicate  $\pm 1$  Standard Error (Bootstrapped For SST) Of The Mean.

Note: DEP =Depression; GAD = Generalized Anxiety Disorder; SST = Scrambled Sentences Test; RT = Recognition Test